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## **Integrated assessment of renewable urban heating systems considering water use, committed emissions and energy justice**

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Transitioning towards renewable heating is important to minimise the use of fossil fuels and abate carbon emissions, because heating accounts for 50% of the final energy consumption and 40% of carbon dioxide emissions globally. In the city of Amsterdam, the Netherlands, the aim is to transition towards renewable heating by 2040 and achieve carbon-neutral heating by 2050 through a neighbourhood-based approach. Such an approach entails that per neighbourhood a renewable heat solution is chosen based on criteria such as carbon emissions, reliability, affordability and feasibility. The impacts of urban heating systems however goes beyond a neighbourhood, and take place on multiple spatial and temporal scales. In this presentation we discuss how a transition towards renewable heating systems can influence the water-energy-land nexus on multiple scales in three ways.

First, heating systems use water locally, but also indirectly through the water footprint embedded in energy carriers. We therefore present an analysis of the direct and indirect water use of heating pathways towards 2050. Second, heating systems which currently have the lowest carbon emissions, may not be the heat option with the lowest carbon emissions in the future. Current decisions for heat options can therefore create non-optimal solutions for minimising carbon emissions in the future. An optimization model to find a mix of heating systems to reduce committed emissions on a neighbourhood scale within a given time period for different scenarios for the insulation of buildings and the decarbonisation of electricity generation is therefore presented. At last, new norms and forms of organising neighbourhood-based heating systems may emerge, potentially creating or exacerbating social inequalities within and beyond the spatial boundaries of a neighbourhood. We therefore present the preliminary results of an analysis on energy justice based on in-depth interviews with urban professionals, dwellers and decision makers in Amsterdam.

By presenting these three studies we aim to address the challenge of multi-scale impacts of transitioning towards renewable urban energy systems and show how energy-water-land nexus research can contribute to decision making for urban infrastructures.